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BEYOND TOMORROW
- A LOOK AT 2050 A.D. -

BY

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United States Army

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In this paper the author projects key trends in energy-source development and environmental concerns toward 2050 A.D. Also projected are trends in political, economic, and environmental interdependence and technological advances in materials composition, biotechnology, superconductivity and information processing. By 2050 A.D. abundant energy should be available from nuclear fusion and fission, hydrogen, solar, hydroelectric, geothermal and possibly other new sources to easily meet the world's needs. Technology will radically alter man-machine interfaces, our concept of work place, and the command and control of military forces. Decisions in three areas primarily will determine what kind of world we will live in by 2050 A.D. The first is space exploration and utilization because a strong commitment here will drive science and technological innovation and maintain U.S. prominence technologically and militarily. The second is our determination to pursue world-wide free trade since that will significantly affect economic development in all nations. The third is how mankind addresses the ethical and moral implications of possible change offered by genetic engineering and medical science.

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USAWC MILITARY STUDIES PROGRAM PAPER

BEYOND TOMORROW
A LOOK AT 2050 A.D.

AN INDIVIDUAL STUDY PROJECT

by

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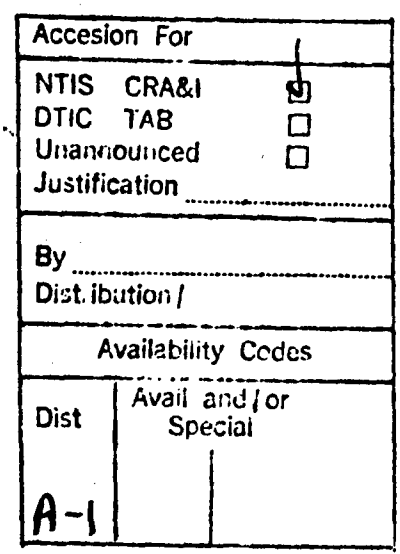

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ABSTRACT

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Our world changes so quickly that it has become increasingly difficult to stay abreast of new developments--much less understand their implications for tomorrow. How will the world of 2050 compare with our present world? If we could design the future world, what kind of life would we build? Can we look the future nearly sixty years and determine any trends that are likely to shape our lives that far ahead? This paper reviews key trends in energy source development and environmental concerns. Political, economic, and environmental interdependence are evaluated for their impact on the national elements of power. General success in food production and storage techniques is anticipated due to genetic engineering developments, local manipulation of weather, and other innovative practices. Technological advances in materials composition, biotechnology, superconductivity and information processing will radically alter man-machine interfaces, our concept of work place and the command and control of military forces. Improved intelligence gathering, transportation and attack systems will permit smaller, flexible forces to replace larger, slower vulnerable forces. Abundant energy should be available from nuclear fusion and fission, hydrogen, solar, hydroelectric, geothermal and possibly other new sources to easily meet the world's needs. Environmental concerns, though a major challenge for the next forty years, will most likely be dealt with through innovative technologies and conservation practices. Decisions in three areas will primarily determine what kind of world we will live in by 2050 A.D. The first is space exploration and utilization because a strong commitment here will drive science and technological innovation and maintain U.S. prominence technologically and militarily. The second is our determination to pursue world wide free trade since that will significantly affect economic development in all nations. The third is how mankind addresses the ethical and moral implications of possible change offered by genetic engineering and medical science.

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INTRODUCTION

"We are made wise not by the recollections of our past but by the responsibility for our future."

-- George Bernard Shaw

Our world changes so quickly that it has become increasingly difficult to stay abreast of new developments--much less understand their implications for tomorrow. We need to be wise in our key decisions to preclude slamming doors on promising changes and to forestall practices that are detrimental to our environment and possibly to our existence. This author agrees with President Nixon who said, "I believe that we must balance our need for survival as a nation with our need for survival as a people. Americans, soldier and civilians, must remember that defense is not an end in itself--it is a way of holding fast to the deepest values known to civilized man."[1]

This paper creates a scenario of a probable world environment for the year 2050. This paper will review current and future trends that very likely will affect global and national policy and strategy over the next sixty years. Readers will hopefully find this enumeration of trends useful in economic, environmental and military planning endeavors. The tone of various sections varies from optimistic to pessimistic, but the overarching trends are grounds for enthusiasm as we approach the future. It seems highly probable that the next six decades will bring greater technological change, fewer wars, more widespread affluence and a more balanced international scene than the previous sixty years.

By 2050, we can almost certainly expect alternative, environmentally safe energy sources to have replaced our present near total dependence on petroleum products for energy. Abundant energy should be available from nuclear fusion and fission, hydrogen, solar, hydroelectric, geothermal and possibly other new sources to easily meet the world's needs. Environmental concerns, though a major challenge for the next forty years, will most likely be dealt with through innovative technologies and conservation practices.

General success in food production and storage techniques is anticipated due to genetic engineering developments, local manipulation of weather, and other innovative practices. Technological advances in materials composition, biotechnology, superconductivity and information processing will radically alter man-machine interfaces, our concept of work place and the command and control of military forces. Improved intelligence gathering, transportation and attack systems will permit smaller, flexible forces to replace larger, slower and more vulnerable forces.

Two subjects, one of which *may* cause concern, and one which *will* very likely cause concern, are population growth and availability of fresh water. Writing on population, Phillip M. Hauser strikes the depths of pessimism: "Given the present outlook, only the faithful who believe in miracles from heaven, the optimistic who anticipate superwonders from science, the parochial fortunate who think they can continue to exist on islands of affluence in a sea of world poverty, and the naive who anticipate nothing can look to the future with equanimity."[2] Presently the World Bank, UNESCO, and others take a much more positive long-range view of

decreasing population growth rates estimating population stabilization between 11 and 12 billion after 2100. However, even this conservative growth rate doubles the current population by 2030.[3] The section on demographics provides further details.

The second subject of concern, fresh water, will most likely come to a head between 2000 and 2050, though the total problem will not be solved until after 2100. Many regional wars may be fought over water as growing populations compete for scarce fresh water supplies.

No matter what the outlook in the advanced and postindustrial countries, the world's long-term prosperity and security depend on economic and political/social development of the heavily populated industrial and preindustrial countries.[4] For example, while Africa's population growth rate exceeds even their healthy three percent increase in productivity, the standard of living for millions continues to fall. Latin America and South Asia are in similar circumstances. Daniel Bell, who headed the United Nations commission on the year 2000, said that the only prediction about the future that can be made with certainty is that public authorities will face more problems than ever before.[5] This author does not hold such a pessimistic view of the future. Even so, conditions during the next 20-30 years will likely produce political hot spots as regional powers confront the interwoven problems of more people, more poverty, a shift toward aging populations and rapid technological change.

A review of key subjects and trends expected between now and 2050 will be followed by a discussion of possible U.S. national and military strategy and force development implications.

The interdependence of nations will propel us toward greater international cooperation to brighten the opportunities for development of all nations. This trend will aim toward more profusely interwoven economics, additional acceptance of United Nations influence and hopefully world peace. Policy makers, strategists and others must consider the roles for military forces as well as technologically induced changes to the conduct of war.

The section on aberrations and long shots briefly attempts to remind us that we are not in complete command of our future. It may help us prepare for some of the **future shock** we are bound to experience through sixty years of progress.

TRENDS

The following trends are this author's views of the trends that will affect how and where we will live, along with the quality of life significantly by 2050. Many of these trends will force ethical and moral decisions as mankind learns more about life forces and is able to manipulate genes to change or preclude certain hereditary and medical conditions. There appears to be a growing number of writers urging readers to evaluate the promised value of new methods or products by their impact on future generations as well as any immediate perceived benefits.

- World population will continue to increase.
  - Rate of growth will diminish.
  - Major population growth in and migration to urban centers and to space occurs.
  - Median age of population rises above 65 by 2050.

- Science, technology, and space utilization will continue to increase dramatically in the following fields:
  - biotechnology (food production needs satisfied).
  - genetics.
  - environmental control.
  - established space stations and colonies on moon & Mars.
  - medical advances (anti-aging relief, exotic diseases cured, extensive brain research, rejection problems overcome).
  - weapons proliferation (conventional & mass destruction).
  - miniaturized cryogenics enable PC-sized supercomputers (rapid data correlation makes artificial intelligence plausible).
  - communications improvements (shared info networks).
  - transportation breakthroughs (people and material movement--local, intercontinental and earth/space).
- Fossil fuels nearly depleted throughout the world, and alternative energy sources including nuclear reactors gain market share.
  - Great strides made to develop renewable energy sources.
  - Light, portable energy plants make particle beam and other directed energy weapons realistic.
  - Power generation decentralization spurs economic development even in remotest areas and eases infrastructure development of cities (includes oxide fuel cells, hydrogen fuel, and waste conversion).
  - Space stations' reliance on and success with solar energy create dissatisfaction with polluting energy sources

- Cheap, renewable energy means that desalinization can provide fresh water in even poorest countries.

• Environmental concerns and knowledge will promote international cooperation to establish and enforce environmental standards, and stimulate innovative methods to control local conditions.

- Current problems will be solved by 2030, though new problems will likely arise by that time.
- Enclosed cities and space colonies with chosen climates will protect humans from environmental hazards.
- Industrially advanced nations will pay for environmentally sound development in preindustrial countries directly, or through debt forgiveness and low-interest loans.
- Nature will be brought into cities through parks, rooftop gardens, etc.

• Economic, political, and environmental interdependence will increase and provide strong motivation for coalescing toward a cooperative world government.

- Geoeconomic competition and conflict will surpass geopolitical concerns.
- Politicians' major role will be to facilitate globalization of economies.
- There will be increased impetus for worldwide free trade.

• Information handling will become faster and more complex while computers and other machines free mankind from boring,repetitive tasks and simple manipulation of statistical data.

- Information continues to double every decade; it is up to users how much of this becomes knowledge for progress.

- Communication with machines will become much easier.
- Cryogenics likely will provide the means to miniaturize information processing machinery.
- Computational speeds increase a million-fold by 2050.

• The question of whether the priorities of society and scientists are the 'best' and most proper ones for mankind will receive increased emphasis.

- As man controls more and more of his environment, in the broadest sense, to what end should he spend his increased leisure time?
- How should we define 'standard of living'?
- Who will control the controllers of information?
- What will be the reaction of religion to novel scientific discovery?

PROJECTIONS BY THE SCORE

This section presents the author's estimates for changes to be expected by the year 2050. The projections are divided into 20-year periods, approximately, and the timing of a particular advancement is less certain beyond 25 or 30 years. Most scientific theory and supporting experimental research is historically completed nearly 25 to 30 years before implementing technology makes the new concept commercially viable. This historic lead-time accounts for the accuracy of short to mid-term projections as well as the decreasing definitude associated with longer-range estimates.

1992-2010

- Population growth: world population approaches 7.1 billion.

- Technological advances:

  - superconductors--cryogenics miniaturized to facilitate production of supercomputers the size of today's Pcs.
  - information processing--increased use of fiber optic cables to speed information transfer at speed of light.
  - stealth technology--greatly improved, to include acoustic stealth.
  - fast trains (magnetic lift and high-speed steel rails) take large share of road transport market from trucks.
  - lightweight, protective battlefield uniform fielded.
  - improved rifle (lightweight, muzzle velocity nearly 4000 meters per second) fielded after the year 2000.
  - electromagnetic gun provides defense against tactical ballistic missiles (TBMD) and cruise missiles.
  - hydrogen burning perfected for vehicles.
  - solid oxide fuel cell becomes commercially viable.
  - unmanned vehicles proliferated throughout the military services for reconnaissance, targeting, and attack of specific targets.
  - Identification, Friend or Foe (IFF) developed for land and sea equipment.
  - advanced walkie-talkie--permits broad spectrum, lightweight communication over variable ranges.

- Nuclear proliferation: 15-20 nations armed with nuclear weapons.

- Genetic revolution: increase food production by 40-200 percent per cultivated acre.

- Initial success of biotechnology:

  - designer microbes that make ceramics.
  - improved catalysis allows leap-ahead in purity of metals.
  - new vaccines eliminate most diseases known today.

- Harvest fog for moisture in semi-arid areas.

- Return of lighter than air aircraft: less energy required; long time on station; less pollution.

- Retired aircraft carriers become floating POMCUS sites or forward operating bases to launch ground units ashore.

- Trend continues toward privatization of government services and industry.

2010-2030

- Nuclear fusion successfully developed for commercial use.
- Solar energy beamed from space via microwaves or cables.
- Moon colonies: probably 100,000 persons engaged in space launch operations and manufacturing in space by 2030.
- First manned flight to Mars/Venus conducted.
- Recovery of oil from tar sands/shale becomes cost effective.
- Geothermal energy becomes readily available: new deep drilling technology matures.
- Increased energy use: by 2030, nearly four times 1990 consumption rate.
- Restore rain forests: reforestation efforts of 1990s reaches mature state.
- Water wars occur in Middle East, Africa, and South Asia.
- International EPA established with enforcement authority.
- Oceans become transparent to 5,000 feet, thus increasing the vulnerability of submarines.
- Population growth slows: reaches 8.8 billion by 2030.
- AIDS vaccine perfected; most other exotic diseases controlled.
- Surface effect ships permit trans-oceanic speeds > 70 mph.
- Hypersonic flight for commercial airlines: dependent on artificial intelligence if navigational control broken during flight.
- Catalysis codes broken: space station manufacture triples purity of various metals.
- Significant move to underground cities: combat urban sprawl, reduce utilities investment, reduce energy consumption, provide protection from increased ultra violet radiation due to ozone layer depletion.
- Surface and submerged ocean cities developed for extended expansion of urban centers.
- Deep Sea Technology: ocean mining and agriculture become growth industries.
- Robotics widespread: home butlers common in upper-class homes.

- Transport:

  - evacuated-tunnel trains travel 3,000-6,000 miles per hour.
  - computerized "grocery-cart" intra-urban systems with interlocking electrical grids, accessed by small electrically powered vehicles.

- Disappearance of traditional heavy armor forces.

- Global monetary unit established.

- Increased United Nations participation and guidance in environmental and economic areas.

2030-2050

- Multiple space stations: many countries develop space colonies to relieve population crowding and to develop space technologies and new industries.

- Population growth rate much reduced: total world population approaches 10.5 billion, but growth rate reduced to range of.35 to .4 percent annually by 2050.

- End of petroleum reserves in sight: OPEC nations searching for alternative sources of income.

- Anti-gravity breakthrough allows partial offset of gravitational attractive force.

- Life expectancy extended to 120 years:

  - retirement age extended;
  - continuous education requirements throughout lifetime;
  - most people serve in at least four different occupations and/or professions during lifetime;
  - leisure activities take on increased prominence--volunteerism is commonplace.

- International peace widespread: localized conflicts continue.

- Democratization of the United Nations gives all nations a greater voice in world affairs and increases its utility as a peacemaker, peacekeeper, and peace enforcer.

ENERGY TRENDS

This subject will be one of the most dynamic over the next sixty years. Though petroleum products will provide the bulk of our energy for the next twenty years, long-term trends are away

from petroleum toward cleaner and, where available, renewable energy sources.

Our energy problems are in three groups: (1) a few countries control the majority of energy reserves[6], except for coal; (2) the expected increases in energy requirements; and (3) the rising concern over environmental consequences of today's energy sources.

As world crude oil requirements exceed 70 million barrels per day by 2000 and if the price remains low, industrializing nations will continue to rely on oil for the preponderance of their energy through at least 2010. At those consumption rates, the known oil reserves of 1002.2 billion barrels will last until about 2030.[7]

Many experts estimate that energy consumption could be reduced by as much as 60 percent through conservation measures, alone. If we assume that appropriate conservation actions occur, then today's production levels of oil and natural gas will support the needs of increasing population (approximately 10 billion by 2050) until 2030-2035. There are probably additional undiscovered oil and gas reserves that will be found when currently known deposits near depletion. Additionally, extraction from tar sands and shale will likely be economically feasible before current reserves are depleted. Through conservation and discovery of additional petroleum reserves, oil may remain the primary energy source on earth until mid-21st century, but only if the resulting environmental impact is either significantly reduced or found to be less important than presently considered.

Twentieth century energy practices are pollution-prone and wasteful. If developing nations attempt to model their growth after the last 150 years in the industrialized nations, our air will soon become hazardous to humans and other animals. For example, in the United States electricity power production generates 35 percent of the emitted carbon dioxide, transportation accounts for 32 percent and the manufacturing sector produces 20 percent.[8] We could reduce these emissions which contribute to global warming by nearly one-third through aggressive energy conservation practices along with more efficient production and transmission of electricity. Carbon dioxide emissions drop one pound for every five pounds of copper produced by electrical induction instead of using furnaces,[9] and a 10 percent increase in automobile and truck fuel efficiency in the United States would save more than one million barrels of oil per day. Steger claims that, "Improving the efficiency of existing oil and gas furnaces and water heaters would save the equivalent of 4.5 million barrels of oil a year."[10] Our electrical distribution systems lose 10 percent of the energy during transmission between production site and user. Improving conductors and developing power production sites closer to consumers would ameliorate this problem.

New technologies must be vigorously pursued--fusion, hydrogen burning, solid oxide or molten carbonate fuel cells,[11] solar, wind, geothermal, and cleaner nuclear fission. David White and others recommend a concentrated federal research program with more balanced research and development (R&D) to develop renewable and non-polluting sources of energy.[12] They vigorously support,

as does this author, a global reactor research program to design a cleaner, more dependable fission reactor for use worldwide and to develop nuclear fusion reactor technology. New energy research successes will most likely come from a determined program to explore and colonize space.

Summary Thoughts

National and international programs are needed to exploit renewable/non-polluting forms of energy, to discover and encourage conservation measures, and to institute and enforce environmentally sound uses of energy. Industrialized nations must be prepared to assist in funding energy development in less developed countries. This will reduce the negative burden on the environment that would result from a development process similar to what current industrialized nations have experienced either out of ignorance or lack of global concern. The postindustrial nations must review " major technological advances before they are launched upon the public"[13] [emphasis added]. Perhaps we need a worldwide tax on future carbon emissions to encourage industry to develop and adopt clean air practices. The United States must take a leadership role. President Nixon clearly set the tone for approaching the future when he said, "I feel that modernization has a moral significance only in those who have another choice. The weak can only plead. Magnanimity and restraint gain moral meaning coming from the strong."[14]

World leaders need to think innovatively. An example of such forward thinking is separating the long half-life actinides in nuclear reactor waste and sending them into space toward the

sun to eliminate the long-term hazardous waste problem. Another major shift from current practice would be for the primary red meat eaters around the world to change to a grain staple diet. Since beef production takes 10 times as much energy to provide the same edible calories as equivalent grain production, perhaps meat should be severely taxed to reflect its higher energy consumption.

The military should set the example for compliance with the Clean Air Act of 1970 and later amendments. Energy conservation must be encouraged and enforced at all levels: in operational units, family housing, and other post facilities. Training simulators must approximate battlefield and other crisis conditions as cost and environmental concerns compel the military to depend increasingly on simulations, thus reducing actual full-scale training operations.

Military R&D must support Department of Energy initiatives to develop vehicle and aircraft engines that use other than petroleum fuels. Strategic mobility, highly dependent upon energy availability, must remain a key component of future decisions in force development.

Because the cheaper energy resources are not uniformly present in all nations and energy requirements are expected to at least double or triple in the next 40-50 years, the United States will likely remain integrally involved in world affairs to guarantee the availability and free trade of those resources. Unless new energy technologies are discovered, regional conflicts over oil, gas and coal within the next thirty years are strong possibilities. After that time, additional energy sources should be

available for all nations such that long-range dependence on oil, gas or coal along with the resultant drive toward conflict will be removed .

DEMOGRAPHIC TRENDS

Population growth estimates for more than one generation are subject to much disagreement. Projections out sixty years into the future are easily computed, though one never knows what validity to associate with such long-term forecasts. Nonetheless, since world population reached its first billion in mid-nineteenth century, there has been much serious discussion about future population expectations. There is some merit to the concern. In the 30 years from 1970 to 2000, the following percentage increases in population are projected: Europe--17.3 percent, North America--32.0 percent, Latin America--99.6 percent, Africa--140.5 percent, Asia--68.2 percent.[15] Longer term projections by the World Bank are shown at Table 1.

Table 1. Long-Term Population Growth Projections

(Population figures in millions)

Year	Annual Increase (millions)	World Pop. (bil)	Growth Rate(%)	Less Dev Pop.	Less Dev Growth Rate(%)	More Dev * Pop.	More Dev * Growth Rate(%)
1985	88.2	4,844	1.74	3,666	2.11	1,179	0.54
2000	92.1	6,204	1.54	4,939	1.84	1,265	0.41
2015	88.7	7,556	1.21	6,237	1.42	1,319	0.22
2025	84.4	8,415	1.03	7,078	1.21	1,336	0.10
2050	37.2	10,035	0.35	8,716	0.41	1,319	-0.04
2100	4.9	11,330	0.04	10,020	0.05	1,310	0.01

* More developed: Europe, USSR, USA, Canada, Australia, New Zealand, Japan

Source: Rodolfo A. Bulatao and others, World Population Projections: 1989-90 Edition (Baltimore: The Johns Hopkins University Press for The World Bank, 1990), xvii.

The World Bank estimates are prominently based on steadily reducing growth rates. It may be useful to bracket those projections to see the magnitude of significantly larger or smaller growth rates. The low side projection might be 0.04 percent reached by the year 2000 which would cap out world population in 2050 below 6.4 billion and in 2100 approximately 6.6 billion. Extreme drought, famine, pestilence, disease, or war could produce this result, but it is not considered likely by United Nations, World Bank or other serious forecasters. The high side projection is somewhat more unsettling, i.e., the growth rate remains at the year 2000 figure of 1.54 percent producing a population in 2050 of 12.4 billion and by 2100 of 25 billion.[16]

A clearer understanding of population changes comes from data such as the 15 million refugees known in the world in 1989, nearly a third from Afghanistan and a third within Africa.[17] These migrations reflect movements of young people looking for a better life, as well as political refugees seeking sanctuary from a hostile government or other death-threatening conditions like war and famine. The United States received 612,110 immigrants in 1989 and 5.3 million from 1981-89.[18] More than 5 out of 6 came to the United States from Asia (280,968) and Latin America (235,167).[19] Most estimates show the United States receiving 500,000 to 600,000 immigrants annually for the next 35 years.

Most authorities forecast the population within the United States to peak prior to 2040 at just over 300 million. Estimates range, however, from a lower, earlier peak of 265 million in 2016, to a high of 388 million by 2040.

All countries will experience increased life expectancies with children born in 2050 in many countries projected to live on average 120 years. Life expectancies over the next 40 years have significant variations within different countries, with developed country's median ages rising rapidly. For example, in the United States, the over-65 persons comprised 13.6 percent of the population in 1990, but will increase to nearly 70 percent by 2050.[20] Americans 85 and over will increase 3 to 4 times faster than the general population and should reach 16 million by 2050.[21]

Urbanization will continue such that by 2050 twice as many people worldwide will live in cities as in 1990. Nearly 90 percent of the increase in the developing world will take place in urban areas, whose populations are expected to rise from 1.15 billion in 1985 to 3.85 billion in 2025"[22]. Worldwide urban numbers will likely reach more than 5 billion by 2050.[23] Cities are growing faster than local or national authorities can cope. Disease and crime lower the quality of life due to shortages of water, housing, sanitation and mass transit coupled with high unemployment. City planners must develop massive infrastructure modernization plans to prepare for the enormous population shifts to urban areas.

Huge megalopolises likely will develop by 2050 in the United States along the eastern seaboard, along the California coast, and in the Columbus (OH)-Cincinnati-Louisville central area. In other world areas, already Tokyo-Yokohama in Japan is considered one city unit. These gigantic collections of people, if managed properly, could be more efficiently run than the original individual cities that make them up, due to efficiencies of scale.

Reduction of administration overhead and more efficient centralization of administrative tasks are usually presented as reasons for improved administration of the megalopolises. Reduced duplications of city services such as police, fire, trash collection, and utilities would seem to also reduce governmental costs. This concept is generally favored by futurists expecting specially trained and very carefully selected expert managers to be placed in charge, vice untrained publicly elected officials.

The chief concern of building these very large, impersonal bureaucracies is more loss of identity and less fixed accountability for government services, producing high levels of stress when citizens can get no closer to the responsible person(s) than a computerized voice or uncaring individual on the telephone. Not all futurists believe that large metropolitan centers are healthy places to live.[24] Urban sprawl will continue as people try to escape the rat-race of large downtown areas. Absolutely key to success in any large city, megalopolis or not, is a viable mass transit system. The urbanization movement along with increased emphasis on energy conservation will create a powerful impetus for developing these people and material moving systems.

Home-based information processing businesses will become more commonplace as computers, electronic networks, and input-output systems such as facsimile and video machines proliferate throughout societies. Champion claims that, "a part of the transition from indusrial to postindustrial society is a migration shift from large metropolitan centers to nonmetropolitan areas."[25] This trend indicates that people in postindustrial countries no longer feel tied to a traditional job center.

Food, or the lack thereof, is cited by experts in many fields as a time bomb about to blow up because of the strain of population growth. Seventy five percent of people today can barely feed themselves and 500 million are severely malnourished.[26] The Green Revolution of the 1960s-70s greatly increased rice and other grain outputs, but population growth and widespread droughts have negated the victory of that period. By 2050, food production difficulties are expected to be eliminated.

We are on the verge of several breakthroughs in science and agriculture which will be known as the genetic or biotechnical revolution.[27] Aquaculture also has a major role in feeding the future world. Aquaculture can feed millions and has low enough start up costs that even the poorest countries can quickly establish this industry. This agriculture industry will receive a big boost when fuel cell or other energy sources become available near the consumers without long transmission lines.

Other trends in food production and packaging include freeze-dried and sealed meals which can remain palatable on the shelf for 18 months or longer. Irradiation techniques are another example of technology assisting the food production and distribution systems. Fast transportation systems will aid in distributing foreign food products while also reducing the energy required to transport frozen cuisine. Here again, energetic space exploration and utilization programs can provide the momentum to develop truly exotic food production and storage techniques.

By 2050 the world can expect kitchens to be nearly completely automated (including inventory control, replenishing, food

preparation, and clean-up). The additional leisure time available to most people likely will foster a resurgence of the homely warmth and intimacy of the farm kitchen. O'Neill expects "that with short work weeks and highly mechanized households most people will treat cooking and drink mixing as creative hobbies, and will devote a great deal of time to becoming expert chefs and bartenders."[28] Robotic butlers will be allowed to take over in the kitchen only when the homeowners are ill, tired, or hurried.

Summary Thoughts

Population growth will almost certainly continue, though at a steadily decreasing rate, until the world population reaches 11-12 billion around 2100.

Africa, Latin America and South Asia will understand that a single necessary step to improved quality of life is to check their rapid population growth.[29] Before this occurs, famine and regional quests for food will result in conflicts that will kill thousands and perhaps millions. The most restless areas will be near the African Horn and other Sub-Saharan Africa, the vicinity of the Indian subcontinent and Mexico. There is a very good chance that improved medical practices and knowledge will continue to reduce infant and child mortality (as high as 13 percent in some countries today), while also extending life expectancies; all these changes should produce a governing effect to promote reduced population growth rates.

Geneti engineering will almost certainly cause an agricultural revolution between 2000 and 2010 which will alleviate hunger if population growth rates continue to diminish. Is there

a limit to the world's food production capability? Yes, but it will only be severely taxed (this author has estimated), if world population exceeds 20 billion. Algae and fish farming in the oceans may be adapted to increase food production and choices.

Cities may move underground to lessen urban sprawl, to take advantage of the constant 54 degrees Fahrenheit temperatures as an energy conservation measure, and to reduce exposure to harmful solar radiation. Urban planners must also consider the need to produce food closer to the consumer.[30]

Available manpower in the 18-44 age group will significantly diminish in industrial and postindustrial societies. Active forces will grow smaller, proportionally more women will be inducted into the armed forces (by 2050, women will outnumber men in the 18-44 age group by 15-20 percent), and greater reliance will be placed on technology to offset the reduced numbers of active forces.[31] Mandatory retirement ages will likely change to 80 or 85 by 2050, or even higher, to allow the military services to better utilize specially trained men and women, and to reduce expensive training costs. Retirement ages in the civilian sector will increase also for similar reasons.

Increased leisure time will fairly certainly change our view of productive uses of time. Future societies can reasonably expect a resurgence of craftsmanship in various fields as people with additional time to learn and practice new skills look for fulfilling hobbies and meaningful, creative endeavors. Many people will return to school multiple times as they prepare to change jobs or just search for increased knowledge. Of course, this schooling might be accomplished through information net-

works, night school, day school combined with part-time work, or full time schooling during transition periods between job changes.

ECONOMIC TRENDS

Economic interdependence of nations will increase dramatically as people search beyond their borders for essential, comfort or exotic luxury items. This international exchange, facilitated by improved communications, faster transportation and increased demands from a growing population, has within this century increased tempo, expanded geometrically and produced some far-reaching economic and ecological implications.

Long term forecasts reveal a further separation between rich countries and poor countries who have not adopted sound economic practices. The majority of populations in Argentina, Ethiopia, Jamaica, Nigeria, Peru, Nicaragua, Uganda, Zaire and Zambia will be poorer in the year 2000 than they are today. Some forgiveness of debts coupled with foreign investment and financial aid will be necessary to save these economies. With this kind of economic assistance, these nations may survive and begin to prosper by 2025-2030, but they will not likely have more than 60-70 percent of their population above the poverty level by 2050. A nation with 50 percent of their population below the poverty level, will take 50-70 years to bring another 40 percent above the poverty level at one per cent annual economic growth rate, and 18-24 years if the growth rate of per capita income is stretched to three per cent.[32]

The above example becomes particularly meaningful for Africa where the growth rate in per capita income is about one percent. If population growth remains unchecked, then most African nations will still have more than 10 percent of their populace below the poverty level in 2050. Using the World Bank's optimistic projections for gradually declining African population growth rates (which this author finds too hopeful), it will still take 25 to 35 years to get 90 percent of Africans above the poverty level.

Developing nations can, however, do much on their own to move forward more quickly.[33]

-- Invest in people, including education, health, and population control.

-- Help domestic markets to work well by fostering competition and investing in infrastructure.

-- Liberalize trade and foreign investment.

-- Avoid excessive fiscal deficits and high inflation.

Trade has nearly doubled as per cent of Gross Domestic Product (GDP) worldwide since 1950 and is expected to continue this upward trend. Increased exposure to external influences may put some developing countries at risk. Becoming a player in the global economy increases a nation's vulnerability to potential interest rate increases, unfavorable trade practices, and weaknesses in financial institutions in lender nations. Global integration also promotes competition and increased efficiency as well as more rapid dissemination of new products and services. Technological advances spread rapidly through free trade practices.

Trade may also become more regionalized.[34] Trade restrictions and even trade wars arising from this inward focus could retard global development.[35]

Weiderbaum, as well as many others, sees three centers of economic strength well into the 21st century: North America led by the United States; Japan and other vibrant Asian rim economies; and the European Community.[36] The successful development of many poorer countries will depend heavily on assistance from these economic centers.

Vinod Thomas and others define five responsibilities of industrial countries and finance agencies applicable now and beyond the year 2050:[37]

-- Defend and extend the liberal order of international trade established after 1945.

-- Ease the flow of capital across borders.

-- Pursue domestic economic policies that promote global saving and steady, non-inflationary growth.

-- Support the transfer of technology.

-- Protect the environment and conserve energy.

Support of these tasks will lay the foundation for a more rapid advance in the developing world and help to reduce the number of preindustrial nations by perhaps as much as 50 percent by 2050. Global economic interdependence may also have the salutary effect of promoting international harmony simply because of the growing economic incentives to avoid the devastation of war.[38] The World Development Report 1991 says about wars, "Far and away, the most important cause of famine in developing countries in recent years has not been inadequate agricultural output

or poverty, but military conflict."[39]

Many believe that geoeconomic competition and conflict will surpass geopolitical concerns as the future driving force in international relations. Such a trend would have significant implications for United States military strategy and defense policies? Perhaps this view of the future lends support for maintaining and protecting a viable defense industrial base.

Summary Thoughts

Global economic integration will continue. Economic growth will remain slow in Sub-Saharan Africa, South Asia and Latin America. With the arrival of new energy sources (2010-2020), there is a good likelihood that all countries will experience growth rates of 4 to 5 percent until after 2050.

A global monetary unit will most likely be widely accepted after 2010.

Continued fragmentation of existing preindustrial nations will create additional fragile economic structures requiring guidance, assistance and training from developed countries.

The United States must correct the economic weaknesses that have made possible the relative growth of Japanese and European economic power. These weaknesses include: federal budget deficit, low savings rate, inadequate spending on nonmilitary R&D and the decline in the quality of the U.S. work force.[40] (It is encouraging to note a 7.9 percent increase for R&D from the 1991 to the 1992 U.S. budget).

The trend toward urbanization (more than 5 billion in cities by 2050) will create horrendous requirements for infrastructure

projects costing trillions of dollars. Continued growth in urban areas will also exacerbate problems of poverty, food shortages, unemployment, and crime. Control of these problems may increase the role of police and national guard/militia-type forces in riot control operations.

Though by 2050 economic pressures may be used more frequently than military force, the United States must still maintain a capable defense force. U.S. leadership must take a sanguine appraisal of the developing world situation and resist force reductions beyond militarily prudent risk.

Below are four problem areas that may adversely affect global economic growth and development between now and 2050:

-- stagnating economies that fail to meet basic needs of their populace.
-- hoarding or overcharging for natural resources.
-- overconcern for domestic/social programs that arrest technological progress and military preparedness.
-- environmental decline that significantly increases famine and/or migration.

INTERDEPENDENCE TRENDS

International interdependence among nations has three distinct varieties: economic, environmental, and political.[41] Nations will most likely become more and more economically interdependent. Strengthened regional economic entities may also assume common, almost nationalistic, characteristics concerning trade external to their region which could create unfavorable trade relations and potential conflict. Most futurists support a

continuing upward trend in international trade, technology transfer and broadened markets. Trade in space will almost certainly grow rapidly with construction and manning of space stations and with sizable settlements on the moon.

This author believes that political centers of power will shadow the economic hubs of the world. This line of reasoning concludes that Europe, Japan plus the Pacific Rim, and the United States with the American Free Trade Zone will control political power for the next 10-20 years. The World Bank, United Nations and many writers share this view.[42]

Other potentially strong political centers will be in China, India, Turkey and Brazil after 2010[43], when Indian and Chinese populations together will total more than one-third of the world population. Manpower, military forces, and natural resources provide Russia with key ingredients for political power. However, a stable government and sound economy, prerequisites for a power center, are not likely to be realized in Russia until after 2010.

Based on recent events, authoritarian political entities are fragile and subject to almost instantaneous disintegration. Democratic governments may also change quickly, but they usually transition through an organized procedure of elections and open debate.

This fractionation of countries will likely continue for the next twenty years until the arbitrary post-colonial national borders are reconciled. Diplomacy and military force may both be necessary to stabilize international boundaries in Africa, South Asia and the Middle East. United Nations membership will likely

continue to grow and may approach 180 countries before regionalization pressures coupled with failing economies begin to drive weaker nations toward political mergers.[44] By 2050 there may be as few as 80-100 nation states (or possibly regional political entities with singular UN representation) remaining. Alternatively, cheaper energy sources combined with growth in information processing businesses may provide strong enough economic bases to sustain the majority of smaller national economies.

As nations strive to move toward postindustrial status, there will likely be a devolution of power in favor of a shift toward a world government. Samuelson defines political interdependence as how nations settle conflicts and what happens if they don't.[45] This shift toward world government would facilitate removing, or at least lessening, irritants between nations such as trade barriers and minor border disputes. The United Nations may be the foundation for this centralized government, however, significant democratization will probably have to occur before most nations will agree to give up sovereignty to a common government. As the number of nations increases, this democratization process may be hampered.

On the other hand, many of the preindustrial nations, particularly in Africa and South Asia, likely will come to realize by 2020 that they are inadequate political entities to economically develop or sustain themselves. They will likely merge in pairs or larger groupings to build synergism and create growth. The resulting decrease in nation states would simplify the move toward a world government. Increased migration to and utilization of space could also provide a welcome relief to poorer

nations with expanding populations and weak economies. Such movement to space would likely counter the impetus to merge, as described above, but would also promote the desirability of a world government to ensure equity and stability in space.[46]

Multinational corporations will surely flourish as they continue to trade nearly unencumbered by national boundaries. Their unique ability to combine economically raw materials, inexpensive labor, the requisite industrial capacity, and an efficient distribution system will assure growth in the future expanding world. Some writers fear the inability of individual nations to tax these mega-corporations fairly or to enforce established environmental standards adequately. Taxation of unscrupulous businesses will remain difficult, while environmental compliance can be sufficiently regulated through the auspices of a world government. Environmental management may provide the initial and strongest catalyst for developing a workable world government.

Environmental interdependence is important for survival of the earth. World leaders may find it necessary to control outlaw nations who consider employing environmental terrorism (such as refusing to comply with internationally approved environmental standards, or deliberately sabotaging another country's ecosystems). Enormous diplomatic energy will be required to establish consensus on environmental standards and to gain compliance with the same. Both economic and political centers will play key roles in this environmental diplomacy. There is better than an even chance that an International Environmental Protection Agency will be established to guide these efforts to protect and pre-

serve our planetary environment.

The costs of adequately protecting the environment will be enormous and developing nations will not be favorably disposed to expend huge monies to comply with rules they perceive to be designed to impede their developmental progress. This will be particularly acute in areas where the more industrialized nations have prospered under much less stringent environmental standards. To offset this perceived inequity, while ensuring compliance with established standards, the postindustrial nations will most likely have to share some of the burden for developing countries.

This support will be very expensive and underscores the critical need to establish strict, though not overly cautious, environmental standards. Environmental issues transcend national boundaries--wind and rain need no passports. Pesticides in acid rain falling on U.S. lands have been traced to those used in Central America, but banned in the United States. Global warming represents another case in point.

Global warming is primarily the result of increased levels of carbon dioxide (CO_2) and other "greenhouse" gases which trap the earth's heat.[47] The earth has been warming up for the past century, but the pace has been accelerating in the last decade.

Global warming is a long-term effect since gases already in the atmosphere will continue to heat the planet for years. Carbon dioxide remains in the atmosphere for 40 years and chlorofluorocarbons (CFCs) for 100 years. If the present rate of emissions continues, the amount of CO_2 in the atmosphere could reach double the preindustrial level by the year 2050. The

earth's surface could then be 3°F to 8°F warmer than today. That may not seem like a significant temperature shift, but consider that temperatures at the height of the last Ice Age were only 6°F to 9°F colder than today.[48] One theory to counter the effects of global warming; the earth could tilt on its axis away from the sun, thus lengthening winters and gradually cooling the earth's surface.[49]

Summary Thoughts

Economic, political, and environmental interdependence among nations will increase throughout the next century. A trend toward world government will likely result in reduced national military forces and greater cooperation to solve conflicts through peaceful, diplomatic means.

Global warming will be with the world for decades if CO_2 levels continue to rise, and no off-setting phenomenon occurs. What can the nations of the world do about it? For one thing, nations need to plant millions of trees wherever possible which can lock in CO_2 for 30-40 years and release tons of oxygen back into the atmosphere while restoring depleted woodstocks. This is a labor intensive, long-term project and may require organized efforts by military forces or paramilitary "environmental corps" similar to former Civilian Conservation Corps (CCC) units in the United States in the 1930s. Future military and paramilitary forces may be required to sample water and other mediums for testing for compliance with established environmental standards.

Global participation will be necessary to counter the ef-

fects of this prospective warming trend. A good start is the recent world agreement to eliminate CFCs by 2000. A slight reduction in air conditioning efficiency, mostly in the present industrialized countries, will be the principal effect of quitting CFC use--a small price to pay if it saves the ozone layer. All nations must work additionally to reduce dangerous vehicle and smokestack emissions, improve mass transit systems, and seek alternatives to fossil fuels to provide a global clean environment by 2050.

Another key environmental issue with international significance is the availability of safe, potable water. Most countries in North Africa and the Middle East have less than one percent of the fresh water per person available in many developed countries. Rapidly growing populations will exacerbate this problem over the next 10 years. Within the next 10-20 years, water access can be expected to create severe tension and very likely armed conflict in two areas in the Middle East: along the Nile River in Egypt, and between Jordan and Israel (competition for the waters of the Jordan and Yarmuk Rivers). See Appendix 1, Environment, for a more complete explanation of present and future environmental challenges.

Nations of the world need a longer planning horizon than has been common since the beginning of the industrial revolution. Gro H. Bruntland, Director of the United Nations World Commission on the Environment and Development, defines specific responsibilities of government and private business, "Environmental protection and sustainable development must be an integral part of the mandates of all agencies of governments, of international organi-

zations, and of major private sector institutions."[50] Perhaps we and our leaders would do well to follow the counsel of the Iroquois Indians who encouraged their wise men to consider the impact of decisions and actions on the next seven generations (about 140 years).

TECHNOLOGY TRENDS

Growth in science, technology, and space utilization will continue well beyond 2050. More facts have been discovered during this century than during all time prior to 1900. Modern society is nearly in information overload. As our information doubles every decade it means that the total accumulation of facts in 1985 was one percent of what we'll know in 2050.[51] Growing knowledge in science and technology increasingly gives mankind choices of how we want the future world to develop.

Biotechnology should yield some of the most striking discoveries over the next several decades. Genetically modified plants and animals will be designed for increased production levels, resistance to disease, and the ability to thrive in harsh, even hostile environmental conditions. The food requirements of the growing world population can easily be met through biotechnology applications (See earlier section on Demographics). "The growth of knowledge in this field will inevitably enable the scientists of the future to regulate and manipulate the fundamental processes of living organisms."[52] This control can be exercised to benefit man or to create an "albatross," depending on the extent societies permit doctors and scientists to manipulate the life processes.

Other areas of biotechnology may also offer valuable results.[53] For example, biotechnologists will probably design microbes to purify materials and to clean up toxic wastes. They likely can design other microbes to clog up engines, to break down welds, and to eat electrical circuits. The military impact of this kind of genetic engineering could be very far-reaching, given long range missile delivery and sophisticated dispersing systems. Command and control centers could be disabled if electric-wire-eating microbes were introduced through air intake systems. Special Operations Forces could significantly disable a mechanized or aviation force by contaminating fuel supplies with undetectable microbes that gum up fuel injection systems.

Many experts believe that medical science will discover most everything about the physical human body, less the brain, by 2050. Brain research will then certainly receive far greater attention than in the 20th century. Efforts to understand the chemical and electrical signalling between the two halves of the brain may help solve some of the medical mysteries of mental illness. This research may also have application toward design of true super computers that can reason and learn which are capabilities far beyond the simple computations accomplished at nanosecond speeds of early 21st century supercomputers.[54]

Medical scientists shall make great leaps forward in medical knowledge beyond controlling diseases. Solutions to rejection problems during organ transplants and skin grafts can reasonably be expected before 2050. If man learns to modify animals genetically so that their organs will not be rejected by humans, might not some animals be raised especially as organ transplant donors?

Also, much work appears to support the possibility that someday we can stimulate nerve and muscle tissue to regenerate severed limbs.[55]

Perhaps the greatest single choice facing the United States, and maybe the entire population on earth, is to what extent the people of the United States are willing to finance space exploration and colonization. As many societies gain more and more control over their earthbound lives, the new frontier of space offers adventure and excitement unmatched since the discovery of the "new world" in 1492.

The scientific, technological, and educational advances which will result from a concentrated effort to explore and conquer space are almost beyond comprehension today. There is immense synergism in such a space exploration goal; the drive for excellence in science and mathematics, the impetus for miniaturization, the integration of many previously disjointed programs, and the spirit of adventure and cooperation engendered by this common goal among disparate peoples are representative benefits future societies might expect to reap.

Space stations. There are at least three distinct uses for early space stations: polar orbit observations, equatorial orbit for interplanetary departures, and remote locations for telescopes and micro-gravity experiments.[56] The United States needs a new space station design that is modular for flexible expansion. The present NASA design will take approximately 17 shuttle launches before it can be manned full-time. NASA should investigate optional designs that could be manned after as few as five or six shuttle loads to allow stations to support all three types

of missions, within the same time and shuttle-launch parameters as the current plan requires to provide only one space station.

NASA should encourage industry to submit competitive design proposals. Once a flexible design is selected and the first space station is operational, continued space station construction and deployment should be turned over to private industry rather than retained as a government program. Nations should consider enterprise zones in space, in which government anti-trust, tax laws, and other regulations that hamper private commercial activity would be suspended for 20-to-30-year periods.

Space colonies. One of the most comprehensive discussions on space colonies is given by Gerard O'Neill as he looked ahead toward the year 2081.

> "A space colony would be an Earthlike habitat outside Earth's shadow, growing its own food and deriving all its energy from the sun. Solar energy, inexhaustible (for the foreseeable future) and ever-present in space, would power its industries. Space colonies would process lunar or asteroidal materials into finished products for the Earth and for other colonies. Unlike the other drivers of change, space colonies are still on the drawingboard, not yet realized. Yet I believe they will transform society during the twenty-first century as much as the automobile, airplane, and radio, none of them in existence in 1881, transformed our world during the twentieth."[57]

Sensors and processing. Very large-scale integrated circuits, expert systems and artificial intelligence, automated

decision-support systems, and pattern recognition are all technologies that will greatly improve the capabilities of sensors and processors. Microelectronics technology, such as computer aided design, will also make a major impact on sensor and processing developments.

Improved man-machine interfaces. Virtual reality, simulators, and voice activations are examples of how technology will improve man's nexus with machines.[58]

Military Impacts of Technology Advancements

Short-term Changes to Military Systems

- Nuclear weapons continue to play important role as a peacetime symbol of military power and influence and to deter enemy use of nuclear weapons.

- Technology improvements of conventional systems can also apply to nuclear systems (terminal guidance, target selection).

- Expect new command and control links, sensor communications, target recognition and fire systems in near-real time (detection to target hit times of less than two minutes, surface to surface, and less than 20 seconds, space to earth.

- Enhanced explosive substances: fuel-air and improved armor piercing.

- Stunning effect weapons could revolutionize armed conflict.

Longer-range Forecasts of Impact on Military Systems

- Space strike weapons will be available to counter ballistic missile threat as well as aggressor nation space capabilities.

- Stealth will be applied to cruise missiles and RPVs.

- Military applications of laser, particle beam, radio frequency, kinetic energy and electromagnetic pulse (EMP) technologies will significantly increase the lethality on the battlefield (electro-magnetic gun technologies,[59] other directed energy weapons).

- Lasers for suppression or defeat of enemy sensor systems and for air defense will be fielded (this can only come about with development of nuclear or other high-output power plants small enough to move with the laser system).

- Robotics: reconnaissance, target acquisition, fire support, and logistics platforms may be roboticized.[60]

- Psychokinesis (PK): if PK, as this phenomenon is often known, is possible and is ever perfected, then its military utility would be tremendous.[61]

- Parapsychological: telepathy, clairvoyance, precognition, as well as psychokinesis, may have military applications.

Nature of Warfare

- Unprecedented attrition and disruption of C3I:

-- factor of time much more critical;

-- role of surprise and deception as primary means to achieve early victory;

-- initial period of war will be very devastating.

- Intense electronic warfare (EW) environment: all military hardware must address electronic counter measure requirements during design and testing phases.

- Conventional war should now be analyzed in terms of dynam-

ics and tempo previously attributed to nuclear war only; dispersion for survivability will become a likely defense measure.

- Precision Guided Munitions (PGM) targeted at key C2 and sensor systems; new defensive systems needed to counter PGMs.

- Defending force must consider preemptive strikes as offense and defense designations become clouded.

- Ballistic and cruise missile ranges increase a nation's self-defense zone to 2,000 km or greater.

- Quieter submarines give defense of coastal waters and/or coastal shores renewed importance prior to breaking the opaqueness of the ocean.

Management and Use of Time

- Reduced reaction time to attacks due to improved transportation and fire support systems.

- Detection to engagement time of less than 10 seconds for targets within 30 km; out to 500 km in 20 seconds.

- Blunt an attacker and create opportunities for offensive operations.

IMPACT ON U.S. NATIONAL SECURITY

The scenario depicted for 2050 finds the United States deeply involved in world activities. Though the United States is not envisioned as isolationist in this paper, that tendency remains possible, and if developed, would create a world scenario giving the United States significantly less power and influence than characterized in this paper. However, in 2050, this author believes the United States will be thoroughly immersed in international affairs politically, economically, environmentally, and

through technological exchange. Few conflicts progress to military intervention, but those that do are swift and lethal.

Progression through the intervening years to 2050 will likely require constant vigilance by the U.S. leadership to ensure our national security interests are protected and to preclude undesirable regional hegemony in critical areas of the world or in space. U.S. leaders must decide if this country truly wishes to become the dominant power in space. Many other nations, or groups of nations, are eager to fill any leadership void the United States might leave. For example, how much control does the United States want to exert over space colonies--either U.S. colonies or someone else's?

The United States must decide just what it means to be post-industrial and what interests are worth protecting to maintain leadership among the nations of the world.[62] The United States will have to address its governmental organizations and other institutions in light of national values to determine which properly support our citizens' needs and desires while maintaining their freedoms. Many potential threats may develop during interim years from heavily armed countries or throughout future decades from technologies abused by unscrupulous national leaders or scientists. Utilization of space and genetic engineering will both require careful scrutiny to preclude monopolization, unfair practices, and misuse. Survival of the United States will be less of a military concern than economical or environmental.

U.S. National Challenges

National challenges as foreseen in 2050 generally fall into four categories, the preeminent of which is our approach to envi-

ronmental standards compliance, followed by centralization of our national government, our national defense, and national scientific and technological efforts.

o Environmental compliance. The principal challenges to our approach to environmental standards compliance are:

- to create national and international standards for environmental protection that are perceived as fair and acceptable to other nations.

- to develop environmental programs that will permit maximum utilization of natural resources while protecting the environment.

- to signal clearly our intentions to ensure compliance with established standards through use of military force or other coercive measures.

These challenges, in all likelihood, might be met by the following national actions. Increased concern over environmental issues will almost certainly develop until technological solutions are found, or until scientifically supported standards are established which allow ongoing practices without harm to earth's ecosystems. Significant improvements in testing and impact forecasting will be necessary before wide-scale acceptance can be obtained. In order to assist the preindustrial and industrial nations to exploit their natural resources fully, while remaining environmentally safe, the advanced and postindustrial nations must provide economic and technical aid and training. This assistance will be necessary to expedite these poorer countries' development without accepting the environmentally harmful practices used by the industrially advanced nations during their

developing years. The United States must be clear about the extent of power, as a nation, it is willing to expend to ensure compliance with established standards. Since national survival could be an issue here, U.S. national leaders probably will demonstrate a strong willingness to employ force when necessary to gain environmental compliance when the effects of the abuse extend beyond the offending nation's borders.

o Centralization of government. Trends such as urbanization, aging of the population, increased leisure time, expansion into space, and prolific communications capabilities will present opportunities to decentralize government, while also providing competing pressures toward standardization and centralization of governmental bureaucracies. Increased world trade and freedom of markets will make it more difficult to determine fair and equitable tax laws. Quantum leaps in transportation and information handling services will permit additional centralization, while better educated, older, and less job-encumbered populations will likely strive for more decentralized government.

o National defense. The reduced military threat to the United States and allies implies a need for a small military establishment that is highly mobile, armed with extremely effective high-tech weapons and support systems. These forces will be fully capable of operating in all environments: land, sea, air, and space. A somewhat larger reserve force will likely be maintained for unexpected contingencies requiring additional armed forces and to provide a military opportunity to fulfill national compulsory service obligations.

The principal challenges to the U.S. national defense by the year 2050 are:[63]

- to acquire and train appropriate manpower to staff a professional military establishment, i.e., active, reserve, and civilian support.

- to devise superior national defense and military operational strategies to compensate for near universal access to technology.

- to develop and procure appropriate advanced weapon, transportation, and C^3I systems.

- to devise means for rapid deployment of forces, on earth and in space, required by national and military strategies.

These challenges to U.S. national defense will likely be met by the following national actions. The intellectual and technical skills required of the military personnel in 2050 will be equal to the advanced information/knowledge service industries.[64] To compete successfully for this manpower, the military must aggressively recruit the best young men and women. These recruiting efforts will be similar to those used in the late 1980's which offered benefits and incentives equivalent to the best entry-level civilian jobs. Some of the most popular benefits of military duty might include travel and duty in space, rigorous training in the leading edge technologies, temporary assistance duty in a preindustrial country, and excellent education assistance during and after service. Military training will continue as a primary means to infuse first and second generation immigrants with American moral and ethical principles.

Training program requirements will likely spawn the establishment of highly specialized, challenging training simulations unaccessible outside of the military. These training simulators will incorporate the best computational, automation and holographic technologies available, while reducing local training area environmental concerns. Simulators will most likely provide historical input for broad conceptual training as well as maintaining historical accomplishments for each participant. Computers will coach trainees on ways to improve after each iteration using cross correlation between the student's most recent performance, his best recorded performance from all previous excursions, and the best performance registered by any prior participant.

Most nations will share in the relatively universal technology exchange common by 2050. Even the slowest developing nations can take advantage of the nominally free access to modern, advanced technologies. This technology transfer, with significant military weapon applications, will tend to reduce any weapons technology edge for the postindustrial and advanced industrial nations. Clandestine "skunk works" and careful compartmentalization of new technology development programs will probably increase as deterrents to undesirable transfer of technology. New and innovative weapon systems will continue to be valuable as compensation for lost monopolies on leading technologies.

National and regional defense strategies should incorporate political and economic elements of power to peacefully settle conflicts and to deter aggression. Conflicts might arise between nations from pressures such as availability of oil (or other natural resources), perceived unfair trade practices, in-

ternational environmental impacts, border disputes, oppression of ethnic peoples, or other threats to national survival. United States' leadership must always encourage nations to use international forums such as the UN to settle disputes between nations. World leaders must exhaust every potential solution to a conflict before resorting to military force.

Superiority on the battlefield will likely come more from national defense and operational strategies than from equipment dominance. These strategies most likely will include methods of gaining surprise (stealth, operating from space, rapid movement of highly lethal forces), and employment of discretely targeted, long-range weapon systems. Surprise may also come in the form of totally non-lethal weapon systems that can stun or otherwise incapacitate adversaries until they are disarmed and, if desirable, captured.

o National scientific and technological efforts. Information known to mankind is doubling every decade, and much of this knowledge is scientific or technological in nature. Available information in 2050 will be 100 times what was known in 1986. More importantly, humans will very likely process information about a million times faster than they do today, which translates into much more efficient use of available information. Knowledge and information handling industries will flourish as people devise efficient methods to distinguish between information and useful knowledge. Retailing this information processing service can be expected to remain a growth industry for centuries. Technological leadership in 2050 will be shared primarily by the postindustrial and advanced industrial nations. Patent protec-

tion, including patent royalties, is desirable and jealously guarded in most scientifically advanced nations. These and similar legal constraints have assisted governments in protecting technologies integral to their national security. There are differing opinions regarding the value of patents and associated laws.[65] The inference of the 2050 scenario is the same as Taylor accredited to his World 2010, that the benefits of technology transfer, "which emanate mostly from the postindustrial and advanced industrial nations, will be available to all nations and almost all nations have the appropriate infrastructure to use the advances except the very poorest of the preindustrial nations."[66]

Where is this deluge of scientific and technological information leading? Muller, in his Uses of the Future, credits scientist Ralph Lapp with the following summation of the state of affairs in any nation that prides itself on its technological leadership: "No one--not even the most brilliant scientist today--really knows where science is taking us. We are aboard a train which is gathering speed, racing down a track on which there are an unknown number of switches leading to unknown destinations. No single scientist is in the cab and there may be demons at the switch. Most of society is in the caboose looking backward."[67]

Despite all the to-do about futurology, our society remains unprepared for the future. Man has always sought power over his environment by both magical and empirical means. However, the Western drive to master nature through technology is not clearly natural or foreordained. In Megatrends 2000, John Naisbitt says, "When we think of the 21st century, we think technology: space

travel, biotechnology, robots. But the face of the future is more complex than the technology we use to envision it. The most exciting breakthroughs of the 21st century will occur not because of technology but because of an expanding concept of what it means to be human."[68]

The many challenges to U.S. national science and technology may seriously destabilize the world and interrupt normal relations with other nations. The following list depicts some of the premier challenges facing the national leadership by 2050:

- the protection of sensitive technology whose loss might jeopardize national security interests.

- the maintenance of a robust Research & Development program to remain a leader in science and technology.

- the control of medical and genetic engineering to ensure society's approval of procedures and to preclude undesirable uses of these technologies.

- the management of space (colonization, clutter in near-earth orbits, flight routes, and repair of satellites in geosynchronous orbit).

- the approaching end of fossil fuels, and subsequent demands for environmentally sound, inexpensive, and renewable energy sources.

Many of these challenges exist today and in all likelihood will persist through most of the 21st century. National decisions to establish policies and strategies to address these scientific challenges must be made throughout the next 50-100 years. Since the science and technology areas are also closely tied to environmental protection and economic development, U.S. national

governmental structure may need to be redesigned. The quickest "fix" to this problem would be to establish a Domestic Development Council patterned after the National Security Council, with focus on national domestic development and environmental protection. Perhaps a Department of Environment and Development should replace several Cabinet-level positions.[69] This structure would parallel the emerging United Nations organization aimed at capturing the synergism of environmentally sound economic and social development. Other actions to meet the science and technology challenges are:[70]

- develop an avowed national policy to prevent unwanted disclosure of sensitive scientific and technological information;

- encourage all nations to pursue peaceful uses of science and technology on earth and in space;

- assist all nations to transfer from fossil fuels to cleaner alternative energy sources;

- encourage expanded peaceful uses of space (medical manufacturing, earth-space and interplanetary communications, weather prediction and localized weather modification, manned space colonies to alleviate crowding on earth, interstellar observations, and mining operations--moon, Mars, asteroids);

- develop international agreements to reduce and control space clutter;

- maximize science and technology developments to correct and/or control aberrant behavior (hypnotic blocks on aggression, parolee monitoring, chemical control of antisocial behavior);

- address potential invasions of privacy which may result from science and technology advancements;

- improve genetic engineering capabilities to prevent heredity diseases; increase agricultural production and adaptation to harsh growing conditions; design organisms that can neutralize toxic wastes, separate designated minerals, construct ceramics and plastics that can replace strategic metals;[71]

- review major technological advances before they are launched upon the public.[72]

U.S. National Security Threats

By 2050, threats to our national security will be linked more to the economic element of power than to the military element. That is not to say, however, that the military threat can be dismissed. Actions by an adversarial nation in space could create significant problems for our much smaller defense forces. Many nations will retain the capability to strike the U.S. mainland using ballistic missiles, a continuing threat since our ground-based ballistic and cruise missile defenses likely will not be dense enough to intercept every potential incoming missile, even with excellent warning from space-based systems.

International terrorism will still be capable of interrupting surface, air, and space transportation nodes, as well as employing dangerous technologies to threaten or blackmail communities and nations. Genetically sculptured bacteria could easily be disseminated into most countries of the world and into space without being detected. U.S. leaders must strive to diffuse potential conflicts before they progress to violence, and when that fails we must apply enough force to end them quickly and with minimal damage to the United States or our allies.

The U.S. national leadership must address how we, as a nation, will confront various threats. Will we rely on a strengthened United Nations for coalition sanctions and possibly force, or will we attempt to resolve each problem diplomatically? We might decide to impose economic sanctions (which by the way, might be extremely effective given the increased economic interdependence of nations by 2050), just as in the 1990s and early decades of the 21st century, before we threaten to, or actually use military force.

Other threats to our national security might be:

- A failure to develop alternative energy sources to replace fossil fuels.

- Inability to properly dispose of toxic wastes, particularly nuclear reactor spent rods.

- The general proliferation of nuclear or other weapons of mass destruction.

Implications for the U.S. Military

The military forces in 2050 in all likelihood will be heavily defensively oriented, though they will retain a significant offensive capability with small, highly mobile, and lethal forces. They will retain the capability to operate on land, in the air, on and under the seas, and in space. In order to engender widespread support for retaining a viable military force, the forces may be employed up to six months each year as an environmental corps. In this capacity, they would assist the economic development of preindustrial and industrial nations by building environmentally sound infrastructures, or they might be assigned

construction and security missions in space.

Potential Military Configurations

The following four possible U.S. military configurations provide a range of force sizes and number of services. The perceived threats, technology advancements, economic pressures, and existing world situation will dictate which military configuration is selected.

- One service, extremely small (on order of 50-60,000) mostly concerned with patrols in space. Additionally, small reserve component (RC) forces (perhaps 200,000) would be available for augmentation. Larger numbers of RC forces would be difficult to train due to lack of equipment, but could be a valuable national asset for assisting developing countries.

- One service, combining land, air, sea, and space capabilities (200,000). This configuration is most likely as it preserves (with combinations of extremely rapid, lethal and nonlethal systems) a substantial defensive and offensive capability, while enjoying the synergy of integrated research and development, acquisition, and training. This configuration would likely maintain a reserve component force of approximately 500,000 men and women, well trained on modern, high-tech equipment and the latest doctrine. These forces could also assist developing nations and space utilization endeavors.

- Three services, air-land, sea and space (280,000). This force might be viable if substantial numbers of conflicts require military solution. This configuration joins the air-land component as a warfighting service, while retaining separate navy and

space components. Reserve component forces would probably exceed 600,000.

- Four services, air, land, sea, and space (600,000). If the trends toward world peace and world government are greatly slowed or reversed, then significant armed forces will be needed. Reserve Component forces could easily number one million. This author does not believe this world situation is very likely, since it does not support the needs of nations moving toward advanced or postindustrial status, where the majority of world power will reside. However, the failure to develop alternative energy sources or a decision not to pursue space exploration and colonization could produce frictions requiring continuance of large standing military forces.

Stephen Kempf's conceptual forces for 2025 A.D.[73] display many of the procedures and equipment present in 2050 forces. The men and women manning these forces must be well educated and bright enough to operate effectively complex, computerized and automated C^3I, warfighting and support systems envisioned for 2050. Sufficient personnel will be available to man any of the four configurations enumerated above. However, if configuration of four services is mandated, then competitive recruiting incentives will be necessary to attract the required high caliber men and women. Extended life expectancies and better overall health will support recruitment of older personnel (initial entry ages of 25-45 may be common) to meet these higher manpower demands.

Battlefield Implications

With the sharing of most technologies, many nations will

possess advanced technology weapon systems. Time on the battlefield becomes a critical factor and makes effective strategies and operational art even more dependent on surprise and deception than today. Defensive protective measures will be required to guard against the unprecedented attrition and disruption of C^3I attempted by aggressor forces. Conventional war must be analyzed in terms of dynamics and tempo previously attributed to nuclear war only. Ballistic and cruise missiles along with the likelihood of weapons in space significantly increase the self-defense zone. Defensive forces must consider preemptive strikes. We may need to protect our industrial base in the United States and other countries even more aggressively since many 2050 nations can hold that infrastructure vulnerable. Nuclear weapons continue to play an important role as a peacetime symbol of military power and influence and to deter enemy use of nuclear weapons.

The military must place continued emphasis on developing and selecting top-quality leaders. Peters and Austin's definition of leadership is clearly in line with future military needs and describes the value of quality leadership in successful businesses. They say that, "Leadership as the liberation of talent, rather than restraint by rule, is a common theme in all our winning enterprises." We must work this outlook to select those for future leadership roles who are willing and able to train and empower their subordinates.

SUMMARY THOUGHTS

The world of 2050 will be an exciting place to live, work, discover, and play. Technology solutions to our most demanding

problems/challenges will likely be found prior to 2050. Whether we recognize and pursue the best solutions will be measured over the next six decades. Robotic butlers, operational space colonies, enforced environmental standards, safe/plentiful energy sources are all within our grasp by 2050. People in 2050 can enjoy ready access to the most up-to-date information on almost any topic through powerful and speedy computers. Responses can be displayed holographically or on wall-sized screens. Major improvements are envisioned for input-output interfaces with computers--we will likely "talk" to computers and even have the capacity to request, order or demand certain responses.

Transportation means will likely undergo some of the most striking changes; underground vacuum tunnel magnetic-lift "railroads" and computerized people-mover systems should be operational and proliferated throughout the country, and much of the world. Our nation will have to make a conscious decision to explore, colonize and use space for economic advantage and for the betterment of mankind, if science and technology are to receive the moral boost and funding necessary to produce these innovative changes.

Population growth rates are forecasted to diminish throughout the 21st century. If that reduction occurs approximately along the lines of the World Bank projections, then the total earth population will stabilize between the years of 2050 and 2100. If the growth rates do not decrease, then space, or the oceans, or underground habitations will have to provide the overflow capacity, or we will have serious conflicts between nations. One of the most significant trends is toward an aging populace,

earning less income and placing high demands on public services.

Transition from predominantly fossil fuel energy to cleaner, alternative energy sources will most likely occur before 2050 in the postindustrial and advanced industrial nations. Nuclear, hydrogen and methane augmented by solar, wind, hydro and geothermal seem to hold the most promise as suitable replacements for oil. The means used to ease this transition will provide a strong indicator of the success or failure of future peaceful conflict resolution.

Economic, environmental and political interdependence is a reality today for most nations and will certainly increase over the next half-century. This intertwining of interests will serve to moderate areas of friction, thus reducing the incidence of armed conflict. If the move toward the United Nations and world government continues, then peace on earth between nations may become a reality. Environmental concerns such as global warming, ozone layer depletion, availability of potable water, disposal of toxic waste, and pollution of the seas can be resolved through cooperation and innovative applications of technology. The principal trading nations must also pursue international free trade if economies are to continue to expand. A world monetary unit will likely be adopted well before 2050.

Control of potentially destructive technologies will be increasingly important as scientific discoveries continue to confront humans with ethical and moral decisions. Genetic engineering, for example, will unquestionably demand significant milestone decisions as research unlocks more and more keys to genetic intercession by man.

The world of 2050 is not thought to be problem-free, but this author is optimistic that most technical problems we can foresee today, will be solved. Though some nations will still face poverty and slow development, the vast majority of nations will almost certainly be moving steadily toward the postindustrial end of the development spectrum. The major challenges will come in discerning what it means to be human, and how mankind can overcome prejudices and perceived hatred of "others" to progress toward harmony and collective enrichment.

ABERRATIONS AND LONG SHOTS

There are many horrible ideas and consequences generated over the years that could override the trends considered in this paper. The following list is not exhaustive, but it may help the reader keep an open mind to possible future shock and resultant shifts from the postulated world of 2050.

- Attack from space: either by another earth country, or by aliens from another planet or solar system.
- Technological breakthrough:
    -- New energy source controlled by only few countries.
    -- Major advances in parapsychology such as the ability to walk through walls or long-distance psychokinesis.
- Uncontrolled proliferation of nuclear weapons and long-range delivery systems.
- Oil reserves drastically less than presently thought.
- A country succeeds in controlling the weather.
- A major natural disaster that affects a large part of the earth and its people.

- AIDS or other exotic diseases mutate to become communicable through sneezes or coughs. No cure found for certain diseases, or we are unable to prevent specific killer diseases.

- Environmental chaos develops because the nations cannot agree on appropriate standards or enforcement measures.

- Population growth continues at current rate and space colonies are not adequate to absorb the growing numbers (This author would not expect even continued high growth rate to pose a significant problem prior to 2100).

APPENDIX 1

ENVIRONMENT

Developing nations face desertification, deforestation, pollution, and the poverty associated with environmental degradation. Industrial nations face challenges of acidification and toxic chemicals and wastes. All countries suffer from ozone depletion, global warming, pollution of land/air/water, and possible future wars fought with nuclear, biological, or chemical weapons.[74]

WATER. Saltwater pollution is an international problem of staggering proportions.

> "Salt water covers 71 percent of the globe, comprises 97 percent of all the water on earth, and contains over 80 percent of all living matter. It warehouses and distributes the sun's energy, serving as a kind of global thermostat which helps regulate the earth's climate. Water provides the cheapest mode of transportation available, and supplies 60 billion tons of food each year."[75]

And how have the people of earth treated such a valuable resource? Humans now put more trash into the ocean than the annual tonnage of fish we take out. Of all the trash that ends up in the ocean, plastic is the worst. Every year almost 100 million tons of plastic finds a new home, floating somewhere in the ocean for up to 450 years.[76] Oil tanker spills account for the third most dangerous saltwater pollution source.

As early as the mid-1980s, U.S. government intelligence services estimated that there were at least ten places in the world where war could break out over dwindling shared water--the majority in the Middle East. Jordan, Israel, and the countries of the Arabian Peninsula are quickly approaching the time when all available fresh surface and ground water supplies will be fully utilized. Algeria, Egypt, Morocco and Tunisia face similar prospects in 10-20 years. Population growth in the Middle East, at the current rate of increase, will exceed 170 million people by the year 2000 (more than a 30 percent increase). Without regional cooperation over water and waste management, burgeoning sewage requirements alone could eventually become a catalyst for armed conflict. Aquifer conflict from over-pumping of shared water reserves may soon become common terminology. Heavy pumping in Gaza has also caused seawater intrusion of its underground freshwater aquifer. "Gaza's water will be unusable by the year 2000, when its population will approach 1 million."[77]

The national security of Egypt is a question of water according to Foreign Minister Ghali in 1991. He has stated that water issues could most easily take Egypt to war.[78] Eight upriver neighbors control 80 percent of the Nile River water that flows through Egypt. Egypt and Sudan will experience severe

water deficit by 2010, both requiring 5 billion cubic meters per year.[79] The water crisis is worsening and adds an extra dimension to prospective war scenarios throughout the Middle East.

Freshwater pollution is a direct concern of man. Water is one of the most basic needs of life as no organism can live without it. Groundwater poisoning is considered by many to be the most pressing hazardous waste problem today. Landfills, toxic waste dumps, leaking underground gas storage tanks and pesticide runoff are the largest contributors to freshwater pollution.

The cost, in terms of health and maybe life itself, of continuing water pollution practices is not known, but human and other lifeforms will undoubtedly suffer until man reverses current destructive actions. Increasing vehicle fuel efficiency by ten percent in the United States alone would save more than 10 billion barrels of oil by 2020.

LAND. Environmental concerns for the land include: soil erosion, toxic wastes and volume of trash in land fills, desertification, deforestation and acid rain. Deforestation and soil erosion go hand in hand. Eleven million hectares of tropical forest are destroyed each year resulting in loss of oxygen release and CO^2 absorption capability, release of tons of carbon into the air, severe soil erosion, and flooding.[80]

In the United States, the percentage of waste to landfills is shrinking--1980 it was 81 percent dropping to 73 percent in 1988, and predicted to be less than 50 percent by 2000.[81] However, landfill capacity has been shrinking even faster. Since 1978, 70 percent of landfills have closed. Nearly half of the 6,000 operating today are expected to close by 1995 when we'll have only 60 percent of the capacity we had in 1985.[82] There are two workable solutions offered: haul it elsewhere (quickly run up against NIMBY-Not In My Back Yard), and speed the process for establishing and licensing new sites. Table 2 compares the waste generation of several nations and clearly demonstrates the upward climb in municipal wastes generated. Note that even though Japan, the former Soviet Union, and the United States are an order of magnitude ahead of all other nations in industrial waste, per capita leaders in municipal waste with twice the levels of any other nations are the United States, Austria, New Zealand, and Canada.

The solution to the waste problem has four components: waste reduction; waste recycling and reuse; disposal; and an institutional framework that binds these together into an efficient and competent whole.[83] Ruckelshaus goes on to say, "...recycling can be coaxed and encouraged, but it cannot be bludgeoned into being by broad statutes that do not take technology and markets into account." Regulations such as those by states requiring newspapers to use a certain percentage of recycled paper have helped. We must remember, however, that recycling won't work equally well with all materials. The United States currently recycles about 13 percent of waste overall. There are some signs of progress:

number of curbside recycling programs has gone from 1,000 nationwide in 1988 to nearly 3,000 today. The number of materials recovery facilities has increased from less than 20 to over 90 in the same period. In 1988, Browning-Ferris Industries, of which Ruckelshaus is Chairman and CEO, had 40,000 recycling customers and now has over 2.2 million and growing by 100,000 per month.[84]

Table 2. Waste Generation Comparisons

	MUNICIPAL WASTE (1,000 MT)			MUN. WASTE Per Capita	INDUST. Waste	HAZ.&SPEC.
COUNTRY	1975	1980	1985	KG	(1000MT)	(1000MT)
Canada		12,600	16,000	630*	61,000	3,290
USA	140,000	160,000	178,000	762*	628,000	265,000
Japan	38,074	41,511	41,530	344	312,000	666
Germany	20,423	21,417	19,387	317	55,932	5,000
Italy	14,095	14,041	15,000	263	35,000	2,000
UK	16,036	15,816	17,737	313	50,000	3,900
Austria		10,000		679*	20,000	300
N Zealand	1,150	2,106		656*	300	45
France		14,000	15,000	272	50,000	2,000
USSR/FSU					306,311	
India					35,722	

Source: World Resources Institute, World Resources 1990-1991 (Oxford: Oxford University Press, 1990), 325.

Desertification is the process whereby productive arid and semi-arid land is rendered economically unproductive. The UN describes it as a "complex interaction between humans, land and climate. The pressures of subsistence food production, commercial crops, and meat production in arid and semiarid areas all contribute to this process. Each year another six million hectares are degraded to desert-like conditions."[85] That equates to an area the size of Saudi Arabia taken out of agriculture every 30 years. Genetic engineering may help fight this problem by designing plants that can survive on little water while holding the soil and slowing the desertification process.
New energy sources like fuel oxide cells or a solar energy conversion breakthrough may also help reverse this loss of productive land. Space technology may also provide light-weight material that could make artificial shade, thus offsetting the effects of global warming which may be contributing to the spread of Africa's deserts.

Acid rain may look harmless, but it is not. It can ruin buildings, destroy lakes and forests/crops, and adversely affect our health. It is caused when nearly invisible dustlike particles of sulfur dioxide (SO_2) from power plants and nitrogen

oxides (NO_x) from car exhaust combine with the water vapor in the atmosphere to form acid-laden clouds. These new compounds can travel hundreds of miles through the air before falling to earth as acid rain, fog, dew, or snow.[86] They may also pick up pesticide hitchhikers and drop them in a different country as was recently discovered when pesticides used only in Central America arrived in the United States in the form of acid rain.

AIR. The earth is one large ecosystem, exchanging gases and nutrients between plants, animals, soil, and the air. Clean air has always been considered a benefit of country living, but as smog production and ozone depletion continue, our pristine air is quickly becoming only a memory. Chloroflourocarbons, or CFCs, are a major culprit in causing ozone depletion. These CFCs come from thousands of products including traditional refrigerants, many plastics and styrofoam packaging, solvents and foam cushioning. Increased ultraviolet rays reaching the earth through the depleted ozone layer are killing the phytoplankton, a basic link in the ocean's food chain, raising the incidence of skin cancer, weakening man's immune systems, may affect large parts of weather systems, and can mutate the genes of plants, potentially destroying billions of dollars' worth of crops affecting our food chain.[87]

Photochemical smog is created by a complex series of reactions between hydrocarbons released by fermenting yeast, evaporating dry cleaning fluid, car exhaust and many other sources. Tiny particles of toxic metals and particulate emissions from industry, from building construction, and even oil-based paints combine with these hydrocarbons and other noxious gases to create a dangerous health hazard. Smog can cause chest pain, triggers asthma attacks, and can permanently damage lung tissue just as cigarette smoke. Abnormal concentrations of carbon monoxide, lead, mercury, arsenic, nickel, asbestos, chromium and cadmium can be absorbed through the lungs into the bloodstream resulting in loss of motor control, headaches and fatigue, and nervous system disorders.

SOLUTIONS. Nations must work diligently together to reduce toxic car exhausts, develop alternative energy sources for making electricity, use mass transportation, walk and ride bicycles more, and use natural cleaners such as baking soda and vinegar instead of many commercial cleaning compounds.

Environmental issues can be solved through conservation measures, technological applications in transportation systems and non-polluting electricity generation, and enforcement of strict standards. Nations must take special care of the Antarctic and Arctic regions because of their enormous relation to weather, to the growth of the phytoplankton at the lower end of the food chain, and to the long-term level of the ocean. A future military force could find itself deeply involved in this enforcement role, either as sampler, tester, or regulating force. By 2050, today's environmental challenges most probably will seem

rather elementary as acceptable solutions should be available and widely adopted, some for more than two generations.

ENDNOTES

1. President Richard Nixon, America's Role in the World commencement address to Air Force Academy, Colorado Springs, CO, June 4, 1969 (Wash, DC: Department of State Publication 8475, June 1969), 8.

2. Foreign Policy Association, Toward the Year 2018 (New York: Cowles Education Corporation, 1968), vii.

3. Victor Showers, World Facts and Figures, Third Edition (New York: John Wiley & Sons, 1989), xx.

4. Charles W. Taylor, A World 2010: A Decline of Superpower Influence (Carlisle Barracks, PA: U.S. Army War College, Strategic Studies Institute, 1986), 2-5, (Hereafter referred to as A World 2010, 1986). Taylor grouped nations according to their relationship to industrialization and modernization: postindustrial, advanced industrial, transitioning industrial, industrial, and preindustrial. In this reference, he describes each in great detail. I have adopted these groupings in this paper.

5. United Nations, World Commission on Environment and Development, Our Common Future (Oxford: Oxford Univ. Press, 1987), 48. (hereafter referred to as Our Common Future)

6. World Resources Institute, World Resources 1990-1991 (Oxford: Oxford Univ. Press, 1990), 320. Africa, South America and the former USSR have significant untapped hydro capacity. The former USSR's untapped hydropower exceeds that currently installed throughout the remainder of the world which now produces approximately 20 percent of all electricity. China, U.S. and the former USSR have more than 75 percent of the known bituminous coal reserves. The former USSR and Asia contain over 70 percent of the world's natural gas. Niger and South Africa hold more than 80 percent of African uranium deposits which is approximately one-third of the known uranium worldwide. Australia has nearly 30 percent of the world uranium reserves. North America also holds more than one-third of the world's uranium, but the price must rise to make mining half of the U.S. and Canada's uranium cost effective (break points taken at less than $80/kg and $80-130/kg).

7. U.S. Department of Energy, Energy Information Administration, Petroleum: An Energy Profile (Washington, D.C.: U.S. Department of Energy, Office of Oil and Gas, 1 August 1991), 14. World oil production from 1859-1989 has depleted approximately 40 percent of the known reserves--647.9 billion barrels produced, 1002.2 billion barrels in known reserves as of January 1, 1990.

8. David C. White, Clinton J. Andrews and Nancy W. Stauffer, "The New Team: Electricity Sources without Carbon Dioxide," Technology Review (January 1992), 42-44; U.S. Department of

Energy, Energy Information Administration, Petroleum: An Energy Profile (Washington, D.C.: U.S. Department of Energy, Office of Oil and Gas, August 1991), 1, 23, 25, 63, (hereafter referred to as Petroleum: An Energy Profile). In the United States from 1970-1990, petroleum consumption increased in the transportation sector 40 percent, in the industrial sector 12 percent, while all other sectors decreased by nearly one-half. For further reading and detail in this topic see: Cetron and Davies, Crystal Globe, 34, 315; World Resources Institute, World Resources 1990-1991 (Oxford: Oxford Univ. Press, 1990), 315, 320; The World Almanac and Book of Facts (New York: Pharos Books, 1991), 555.

9. White, 50.

10. Will Steger and Jon Bowermaster, Saving the Earth: A Citizen's Guide to Environmental Action (New York: Alfred A. Knopf, 1990), 182. This is the same amount of oil that is believed to lie under the protected areas in Alaska and Canada.

11. "Future Scope--Fuel Cells for Clean Energy," The Futurist, Jan-Feb 1992, 8. Pollution-free cells could generate electricity wherever needed. "A clean, efficient, and versatile power source called the solid oxide fuel cell may be commercially available by the turn of the century." Dept. of Energy and Westinghouse Electric Corporation in Pittsburgh have initiated a five-year effort to develop the ceramic-based technology. These fuel cells could generate electricity without air pollution and efficiency losses of thermal-combustion. They can maintain continuous operation as long as fuel is supplied--either cleaned coal-derived gas or natural gas. Multiple cells could be linked to form large-capacity power plants. This approach could significantly reduce the losses inherent with long transmission. A power module for an apartment complex would fit into a small room.

12. David C. White, Clinton J. Andrews, and Nancy W. Stauffer, "The New Team: Electricity Sources without Carbon Dioxide," Technology Review, January 1992, 50.

13. Alvin Toffler, Future Shock (New York: Random House, 1970), 392.

14. President Richard Nixon, America's Role in the World, Commencement address to the Air Force Academy, Colorado Springs, CO, June 4, 1969,Department of State Publication 8475, (Wash, D.C.: U.S. Government Printing Office, June 1969), 9.

15. UNESCO, Statistical Yearbook 1988 (Paris: UNESCO, 1988) 1-1.

16. This tremendous growth in population would populate every square mile of land to the same density in 2050 of Indonesia today (215/mi^2) and in 2100 equal to twice that. Problems would also arise in specific locations because the population would not be evenly distributed over all lands. Compare those densities to today's average of 84.6 persons per square mile (nearly 8 acres

per person), but also compare them to Bangladesh in 1990 with 1810 persons per square mile (approximately 3 persons per acre) and Hong Kong with 14,000 persons per square mile (approximately 17 meters by 10 meters of area per person).

17. Information Please Almanac Atlas & Yearbook 1991, 44th Edition (Boston: Houghton Mifflin Co., 1991), 773.

18. Ibid., 807.

19. Ibid.

20. Ibid., 790.

21. "The Coming Crisis in Long-Term Care," The Futurist (Jan-Feb 1990), 49.

22. Our Common Future, 56.

23. Rodolfo A. Bulatao and others, World Population Projections: 1989-90 Edition (Baltimore: The Johns Hopkins University Press for The World Bank, 1990), 27. Current and projected urban growth is "large-city" oriented. Cities with more than four million inhabitants increased from 12 in 1980 to 23 in 1990; this number is expected to exceed 60 by 2000 and 170 by 2050.

24. Frank George, ed., Science Fact: Astounding and Exciting Developments That Will Transform Your Life (New York: Sterling Publishing Co., Inc., 1978), "Medicine and Surgery: to 2001..." by John Newell, 71. "From every point of view, if humanity is rational we can expect the richer nations of the world to move towards a simpler, plainer, more small-community-minded life-style. If they/we don't do it voluntarily, they/we will be forced to [do] it anyhow."

25. Alden Speare, Jr., review of Counterurbanization: The Changing Pace and Nature of Population Deconcentration, edited by A.G. Champion, In Population and Development Review 17 (September 1991): 540.

26. Orville L. Freeman, "Meeting the Food Needs of the Coming Decade," The Futurist (Nov-Dec 1990), 15. More than 15 million children die each year from starvation and related illnesses (more than 41,000 every day). Since 1980, Africa's population has grown 3% annually while food production has improved only 1.8% annually. India tripled its wheat harvest from 1965-1983, but it has not increased grain production since then, yet its population continues to grow faster than 2% per year (882 million in 1991).

27. Orville L. Freeman, "Meeting the Food Needs of the Coming Decade," The Futurist, (Nov-Dec 1990), 15-20. Gary Stix, "Firewater Fish," Scientific American (August 1991), 99-100. Scientists at the University of Missouri are perfecting genetic designs which will permit most plants to fix nitrogen from the air

just as legumes naturally do. This genetic engineering will significantly increase yields (estimates range from 40-200%) while diminishing the need for commercial fertilizers.

Other genetic feats anticipated in the next 10-15 years are engineering rice to produce more protein while making the leaves, roots and stems edible. Genetic engineering will produce plants that can thrive in salty soil and probably require less water to reach maturity. Other expected successes will be: changing annuals to perennials so that, for example, farmers won't have to replant corn each year; and causing grain crops to produce enzymes that will assist undernourished humans to process beta-carotene. This latter design could be a major breakthrough in reducing blindness caused by malnutrition.

A farmer can reasonably expect 1 million gallons of water to produce 1 million pounds of fish annually. The Early Times Kentucky Whiskey company is using fish to recycle 10,000 tons of spent grain mash (corn, rye and malted barley) annually. They recover vast amounts of otherwise lost heat from the distilling process to the "fish tank" which helps maintain the required 83°F water temperature. This indoor arrangement yields 200 times the production of their outdoor ponds. They have considered tilapia and catfish, but are converting to hybrid striped bass which today are marketed for $3 per pound or four times current catfish prices.

28. Gerard K. O'Neill, 2081: A Hopeful View of the Human Future (New York: Simon and Schuster, 1981), 139.

29. Statistical Yearbook 1988 (Paris: UNESCO, 1988), 1-13. The largest area of world population growth from 1990-2000 is expected to be throughout Africa at 3.1 percent. This growth is expected to drop gradually below two percent by 2050. Compare that to the current world average growth rate of 1.6 percent. Africa's growth rate has increased from 2.9 percent (1970-1980) to 3.0 percent (1980-1990). There were 15 countries whose actual growth rates for the period 1976-1986 were above two percent. Ethiopia, Pakistan, and Iran had the largest growth rates, 4.59, 3.18, and 3.14 percent respectively for this same period, while 12 others ranged between 2.85 and 2.06 percent. Offsetting growth rates were China, 1.68; South Korea, 1.49; USA, 1.17; former Soviet Union, 0.92; Japan, 0.72; and West Germany, -0.08. Estimates suggest that from the turn of the century to mid 21st century the average world population growth rate will continue to decrease from 1.21 to 0.35 percent.

30. The Futurist, Jan-Feb 1992, 41. Greenhouse gardens on rooftops, bus-stop aquaculture (basically anywhere there is sunshine) and engineered growth chambers (controlled temperatures, controlled CO_2 levels and insect-free) can greatly increase food production while reducing storage and transportation costs.

31. Worldwide competition will increase for younger people as the 0-24 age population rapidly decreases over the years. In 1990, this age group comprised 51% of the world population, but by 2050, the 0-24 year-old group will be less than 40% worldwide, but only 26% in the U.S.

32. Our Common Future, 50,51. A graphical portrayal of the long-range impacts of poverty and low growth rates is found in this United Nations example: a nation has 50% below the poverty line, i.e., the individual or household cannot afford on a regular basis the necessities of life. Assume income is distributed as shown--1/5 = 50% of income, 1/5 = 20%, 1/5 = 14%, 1/5 = 9%, 1/5 = 7%--and up to 25% of the incremental increase during the period from the wealthiest group is evenly distributed to the remaining 4/5 of the population (through taxes or otherwise). The total national income must be doubled to reduce poverty levels from 50% to 10%. Timeframes required for this change are shown below:

18-24* yrs at 3% growth in per capita income
26-36* yrs at 2% growth in per capita income
51-70* yrs at 1% growth in per capita income

* The shorter period within the time ranges assumes 25% of the wealthiest group's increase is redistributed, and the longer period assumes no redistribution.

33. World Bank, World Development Report 1991: The Challenge of Development (Oxford: Oxford Univ. Press, 1991),148. (hereafter referred to as World Development Report 1991)

34. William Nolling, "Fortress Europe? The External Trade Policy of the European Communities," Basic Statistics of the Community 26th edition (Frankfurt, 1988), 31. In 1960 before the Common Market, more than 60 percent of the foreign trade of twelve European Community (EC) members was outside the EC. Now, over 60 percent of their trade stays in the EC. This percentage will probably rise further and like trends may develop among the Pacific-rim countries and within the Americas.

35. For example, world trade collapsed with the stockmarket from $3 billion in October 1929 to $1 billion within a year and a half. The resulting hostility toward trade caused damage to world trade that took decades to repair.

36. Murray Weidenbaum, "The Business Response to the Global Marketplace," The Washington Quarterly (Winter 1992), 174.

37. World Development Report 1991, 148.

38. Weidenbaum, 183.

39. World Development Report 1991, 2.

40. Samuel P. Huntington, "America's Changing Strategic Interests," Survival (Jan-Feb 1991), 11.

41. Robert J. Samuelson, introduction to The Economist Book of Vital World Statistics (New York: Times Books, Random House, 1990), 4-6.

42. An interesting, yet minority view of Japan's future is presented by Martin Cetron and Owen Davies, Crystal Globe: The Haves and the Have-nots of the New World Order, (New York: St. Martin's Press, 1991), 132-140, (hereafter referred to as Crystal Globe) where they make a case for a significant drop in Japan's economic might by the year 2000. They argue that Japanese firms are overextended on credit, that the younger generations are self-centered (thus a changing work ethic), and that the aging population (16% of population over 65 by 2000) reduces the productive work force and drains national resources. However, even if Japan's economy declines, Korea, Singapore, Taiwan, and Hong Kong can maintain the Pacific Rim strength.

43. These nations were 2d, 4th, 7th, and 20th, respectively, in size of military forces in 1988.

44. Some authors estimate serious fragmentation of existing nations could create as many as 300 nation states before the upward trend is reversed. This seems much too large a number considering that many nations are fragile economically.

45. Samuelson, 6.

46. What laws apply in space? How will crime be prevented or punished? How many people will go to space before crime moves into space with them? Answers to these and similar questions will require lengthy coordination by lawyers around the world.

47. "Rx for Planet Earth," Great Decisions, Prepared by Foreign Policy Association (Hanover, NH: Dartmouth Printing Co.,1992), 47-56. There is growing scientific consensus that significant global warming due to greenhouse gas emissions is probable over the next century and that rapid climate changes are possible, with disastrous consequences for planet earth. The greatest change in temperature is likely to occur during the winter in the high latitudes of the northern hemisphere. In the middle latitudes, winter temperatures would probably increase more than summer temperatures and the rain belt would shift northward. Forests would begin to die, agriculture would likely be less productive and the grain belt could shift northward to Canada and Siberia. In the southern latitudes, Third World countries would be hard hit. Rainfall would likely decline in Sub-Saharan Africa compounding the existing drought. Rain forests would get hotter and wetter and more intense tropical storms would develop in warmer equatorial waters.

48. Ibid. With only a few degrees rise in temperature, rainfall would be affected and rice production could be reduced with drastic effects on the primary food supply of Asia. Sea levels might rise by 1.5 to 6.5 feet with a rise of three feet likely in the next century. This would displace one-fourth of the world's

population living in coastal areas. The eastern U.S. coastal seaboard would be severely damaged unless billions are spent earlier on seawall construction. Major port cities around the world such as New Orleans, Amsterdam, Tokyo-Yokohama, and Shanghai would be seriously damaged without extensive protective seawalls. Low lying countries like Egypt, in the Nile delta, and Bangladesh would be totally inundated by a three foot rise in sea level and their surviving populations would become refugees. Additional information about global warming can be found in the referenced article and in Will Steger and Jon Bowermaster, Saving the Earth: A Citizen's Guide to Environmental Action (New York: Alfred A. Knopf, 1990), 3-25.

49. Robert Weil, ed., The Omni Future Almanac. With foreword by Ben Bova, (New York: Harmony Books, 1982), 288.

50. United Nations, World Commission on Environment and Development, Our Common Future (Oxford: Oxford University Press, 1987), 312. (hereafter referred to as Our Common Future), 312.

51. Robert Weil, ed., The Omni Future Almanac, With foreword by Ben Bova (New York: Harmony Books, 1982), 288

52. Frank George, ed., Science Fact (New York: Sterling Publishing Company, Inc., 1978), 108.

53. Joel P. Clark and Frank R. Field III, "How Critical are Critical Materials?" Technology Review (Aug/Sep 1985), 46. Ceramic alloys and plastics may replace most needs for strategic metals. "Tomorrow in Brief," The Futurist (Jan-Feb 1992), 5. "Fibers from flax, wood, and cotton could one day take the place of conventional reinforced plastics. Researchers at the Univ. of Wales are chemically altering such plant fibers into environmentally friendly 'biocomposites.' The advantages are the lightness and low costs of the natural composites, as well as lower energy input and easier disposal. Plant fibers can be as strong as glass and carbon fibers, but they tend to absorb water--a problem that the researchers have developed a patented process to solve. One result may be a new, renewable, high-value crop for farmers."

54. "Tomorrow in Brief," The Futurist (Jan-Feb 1992), 6. "A computer program can now listen to a spoken passage and automatically identify the language used." Has already been tested in 15 languages and should prove helpful in the near-term for directory assistance.

55. An opossum has already regrown a severed foot with three toes. This could have far-reaching implications for injured persons and maybe even for children with birth defects.

56. Michael A. Dornheim, "Veteran Designer Offers Reconfigurable Alternative to NASA Space Station," Aviation Week & Space Technology (January 13, 1992), 54.

57. O'Neill, 2081: A Hopeful View of the Human Future, 61-62. He selected five drivers of change: computers, automation, space colonies, energy, and communications. O'Neill goes on to say that space colonies will bring about fundamental change from an economics of scarcity to an economics of abundance. Using the limitless (in human terms) resources of our solar system including the nearly free and non-polluting solar energy, we can escape the confines of Earth and greatly reduce many of the causes of conflict.

58. The Futurist (Jan-Feb 1992), 6. "A computer program can now listen to a spoken passage and automatically identify the language used." Michael Savic is working on this project at Rensselaer Polytechnic Institute. It has already been tested in 15 languages with concentration on English, Spanish, Hindi, and Mandarin Chinese. This capability should prove helpful in directory assistance and other man-machine interfaces. Synthetic holography will significantly increase storage capacities and access-to-data-times of computers. MIT's Media Lab is working on personalized technologies to enable computers to know and serve their human masters in the manner of an English Butler.

59. "USAF Expands Rail Gun Facility to Allow Open-Air Firing Tests," Aviation Week & Space Technology (August 22, 1988), 42. The electro-magnetic rail gun represents the most promising defense system against tactical ballistic and cruise missiles. On Okaloosa Island near Eglin AFB, the tests of the rail gun are impressive. Tim Aden, Eglin deputy for Strategic Defense, said"The replacement rail gun has achieved projectile firing velocities of 1.2-1.3 km/sec with 30mm projectiles. The potential applications are becoming real very quickly. We're no longer looking at popguns firing bullets the size of your little finger. Today, we have a 70-mm gun and a 90-mm gun." We may even see the United States and friendly countries ringed with this type weapon similar to the coastal artillery installations circa World War II.

60. Alcestis R. Oberg, "Space Robots," OMNI (August 1984), 26. Repair of weather and communication satellites at 22,300 miles in geosynchronous orbit (GEO) is difficult because of the hostile radiation environment for humans. Telepresence, or remote human operation of robots using optical sensors to view the surroundings and the human brain to decide which actions are appropriate, will have a growing market as the need for satellite servicing continues to expand.

61. Sheila Ostrander and Lynn Schroeder, Psychic Discoveries Behind the Iron Curtain, With introduction by Ivan T. Sanderson, (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1970), 84-85. The Soviets and their Warsaw Pact cohorts from Bulgaria and Czechoslovakia have conducted extensive research into various psychic phenomenon. Few areas have received the attention that PK has. For example, Ostrander quotes Dr. Alexei Gubko of the Ukrainian Institute of Psychology, 'We'll use PK and ESP in education and in mental control of machines.' "Other Soviets

say, 'We'll use this bio-energy in physico-chemical processes and in medicine.'" Other research has investigated biomagnetism. If man learns to control electrical relays and circuits through PK, then nuclear missile silos, bombers, electrical power plants, and entire cities could be radically affected.

62. William L. Langer, Goals for Americans, comprising The Report of the President's Commission on National Goals, administered by The American Assembly (Columbia University: Prentice-Hall, Inc, 1960), 299. Langer declares that two principal objectives of the United States in world affairs "... are to safeguard its own way of life, and to promote liberty, well-being and progress of all mankind. These objectives call for the defense of the independence of nations and for the reduction if not the prevention of friction and conflict between them."

63. Adapted from Taylor, A World 2010, 1986, 31. These three challenges described for a world 2010 are equally applicable for 2050.

64. Taylor already identified this requirement for quality military personnel in his World 2010, 1986, and it will surely remain as stringent in 2050.

65. Burnham Putnam Beckwith, The Next 500 Years: Scientific Predictions of Major Social Trends (New York: Exposition Press, 1967), 110. Beckwith posits that, "by A.D. 2100, patent royalties will be abolished or paid by the state rather than by producers because they measure no real cost of marginal output."

66. Taylor, World 2010, 1986, 32.

67. Herbert J. Muller, Uses of the Future (Bloomington, IL: Indiana University Press, 1974), 44.

68. John Naisbitt and Patricia Aburdene, Megatrends 2000: Ten New Directions for the 1990's (New York: William Morrow and Company, Inc., 1990), 16. He goes on to say, "Though we will be guided by a revived spirituality, the answer will have to come from us. Apocalypse or Golden Age. The choice is ours. As we approach the beginning of the 3rd millennium, the way we address that question will define what it means to be human."

69. Fifteen cabinet-level agencies is just too many for adequate focus on domestic development. One alternative submitted for consideration is to combine the Department of Energy, EPA, Department of the Interior, Department of Commerce, and a portion of the Departments of Agriculture and Transportation, in order to streamline domestic development. This concept would reduce the federal bureaucracy at the cabinet level, but may produce a span of control too large for one person. Another restructuring plan calls for a hard-line paring of duplicate functions between and within existing departments. For example, at least four departments (Commerce, Energy, State, and Defense) are each tasked to monitor technology transfers from the United States. Still an-

other means to reduce the President's span of control would be to have three to four Vice Presidents, each with oversight of four to five executive departments; however, this approach would require a constitutional change.

70. Adapted from Taylor's World 2010, 1986, 32-33. Many of these actions will require attention throughout the 21st century. Taylor's insight in 1986 was far-reaching and many of his proposed actions and accomplishments for 2010 remain applicable in 2050.

71. The Futurist, Jan-Feb 1992, 40-41; Theodore J. Gordon, 'The Year 2050: reflections of a futurist," The Lamp (Bayonne, NJ: Standard Oil Co., Spring 1981), 26-31; Taylor, World 2010, 1986, 33.

72. Alan Toffler, Future Shock (New York: Random House, 1970), 392.

73. Stephen J. Kempf, Future Perspectives, Individual Study Project (Carlisle Barracks, PA: U.S. Army War College, 3 Apr 1986), 20-31. The first configuration hypothesized for 2050 with emphasis on space patrols, would obviously not have the heavy forces depicted by Kempf. All other 2050 military force configurations would likely require a combination of forces very similar to those depicted by Kempf. The only technological longshot in producing these forces is some sort of antigravity drive for the heavy 200-ton battle vehicles. These battle vehicles "...are capable of traversing all terrain at 250 mph, are impervious to ballistic and directed energy weapons, and capable of confusing enemy sensors." Two categories of fire support vehicles are envisioned, "self-propelled rocket-guns are heavily armored and designed to function as mobile artillery and long -range fire support and the precision missile carriers that are designed to provide immediate fire support to infantry battalions as close assault vehicles to demolish strong points." Light force soldiers are "outfitted in a personal environmental suit that is ballistic resistant to all kinetic small arms, flame/heat resistant to directed energy weapons," and provides protection against biological and chemical agents. This articulated battle armor has its "own microcomputer in each suit to help soldiers track targets, evade detection, and control hand launched weapons, use kinetic energy and directed energy weapons to fight alongside the armored vehicles." Kempf's Strategic Support Force provides "strategic command, control,and communications, automation, data bases, holographic projection support, surface and subsurface mapping, intelligence expert systems and integrated fire support for operational planning and execution."

74. United Nations, World Commission on Environment and Development, Our Common Future (Oxford: Oxford University Press, 1987), 308-9. (hereafter referred to as Our Common Future).

75. Steger and Bowermaster, Saving the Earth: A Citizen's Guide to Environmental Action, 169. "As the atmosphere heats up, so does the ocean. Beneath the surface the ocean roils and churns, influenced by the heat of the sun, the Earth's rotation, and solar and lunar tides. Rivers as wide as states carve channels miles below and, propelled by fast-running currents, carry tons of water (and sludge and trash) over long distances. Their movement is as difficult to predict as that of the skies. Without this constant movement, northern Europe might feel more like the Arctic." Global warming may yet influence the ocean in ways unknown to man.

76. Ibid., 183.

77. Joyce R. Starr, "Water Wars," Foreign Policy, Spring 1991,-26.

78. Ibid., 28.

79. Ibid., 22.

80. Our Common Future, 30. We've seen a rising incidence of disasters with the 1970s having six times as many deaths from natural disasters as in 1960s. Most of these deaths were caused by deforestation and overcultivation. Floods alone affected 15.4 million people in the 70s compared to 5.2 million during the 60s.

81. William D. Ruckelshaus, "Solid Waste in America," Vital Speeches of the Day vol. 58, No. 24 (delivered before the Cleveland City Club, Cleveland, Ohio, June 21, 1991, 1 Oct 1991), 767.

82. Ibid.

83. Ibid., 766.

84. Ibid., 767.

85. Our Common Future, 34.

86. Steger and Bowermaster, 85. The world's more than 400 million cars are major contributors to the acid rain problem. Only Canada and the United States require catalytic converters on cars which nearly eliminate nitrogen oxide emissions.

87. Ibid., 40.

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